SHORT COMMUNICATION

A herd immunity approach to the COVID-19 pandemic?

Yoshiyasu Takefuji[1] ⬤

Abstract

Viral contamination is one of the most urgent and important topics of environmental pollution. COVID-19 is primarily transmitted from person to person, but can also be transmitted from person to animal. Herd immunity must meet the requirements in order to fulfill the goal of mitigating and ending COVID-19. This paper shows five reasons or conditions why herd immunity is not achieved in the present policies without proposed effective strategies in this paper. Unless one of the five reasons for the herd immunity model is met, the promise of herd immunity will not be fulfilled. Many COVID-19 policies worldwide with current vaccines do not meet the requirements. Policymakers have been relying on unreliable R. The number of daily deaths instead of the number of cases is a good indicator of the pandemic which will be mainly used in this paper. Currently, even in vaccinated countries, resurgences are being observed with new variants with spike mutations and immune escape. This paper proposes an effective multipronged approach such as a pharmacological approach and a non-pharmacological approach including digital fencing. Two tools such as scorecovid and deathdaily were used for justifying the claims. Digital fencing as well as pharmacological approaches may be able to overcome the pandemic. Two tools such as scorecovid and deathdaily showed that the proposed multipronged approach will be effective for mitigating the pandemic.

Keywords Herd immunity · COVID-19 · Spike mutations · Immune escape · Digital fence

1 Introduction

The purpose of this paper is to propose an effective multifaceted approach, including pharmacological and non-pharmacological approaches.

This paper presents the important issues in successful herd immunity with herd immunity threshold. Five reasons or conditions of herd immunity will be addressed. Unless one of the five reasons for the herd immunity model is met, the promise of herd immunity will not be fulfilled. Two tools such as deathdaily [1] and scorecovid [2] will be introduced to solve two conditions of herd immunity.

This paper shows how to overcome the five conditions in the near future. Vaccines were initially effective and successful in mitigating the pandemic, but current vaccines do not support new variants with spike mutations and immune escape. This paper shows evidences of policy failures in vaccinated counties against new variants.

The first new tool called deathdaily can detect symptoms of pandemic resurgence or policy failures. The vaccination is a pharmacological approach.

The second new tool, scorecovid discovered that digital fencing against COVID-19 is quite effective. Digital fences are briefly introduced to mitigate and end the pandemic with improved or new vaccines in this paper. PyPI packaging allows deathdaily and scorecovid to run on Windows, MacOS, and Linux operating systems respectively.

Three difficult issues in herd immunity such as new variants, uneven vaccines worldwide, and human behaviour changes of vaccinated people must be overcome. A new vaccine must support new variants with spike mutations and immune escape. Vaccines are not evenly distributed around the world. Human behaviour changes of vaccinated people contribute to the spread of infectious diseases.

Herd immunity or population immunity is a concept in which a population can be protected from a virus if enough people possess immunity [3]. Current accepted estimates for the "herd immunity threshold" range from 60–90% of the population [1].

✉ Yoshiyasu Takefuji
takefuji@keio.jp

1 Faculty of Data Science, Musashino University, 3-3-3 Ariake Koto-ku, Tokyo 135-8181, Japan

The herd immunity threshold refers to the percentage of the population that needs to become immune to an infectious disease so that people without immunity aren't likely to interact with an infected person and become infected [2]. Rubin stated that the threshold range is between 70 and 90% of the population being immune, either through natural infection or vaccination [4].

Anthony Fauci predicted that 70 to 85% of the United States population may need to be vaccinated to achieve "herd immunity" against SARS-CoV-2 [5].

According to Fine [6, 7], herd immunity is a theory based on statistical models rather than a rigorous syllogism. Statistical models assume that several conditions must be met. For example, in their models, the effectiveness of the vaccine must be constant [6, 7].

Murray addressed why herd immunity is not an effective strategy until a vaccine has been developed and distributed [8]. Until the arrival of vaccines, many countries except several countries with digital fences have been suffering COVID-19 because they did not have any effective strategy against COVID-19. None of the herd immunity studies have served the purpose of pandemic mitigation.

Digital fences have significantly reduced the spread of COVID-19 in Taiwan, China, South Korea, Australia, New Zealand, Iceland, and UAE respectively [9, 10].

In digital fences, the system detects phone signals with mandatory coronavirus apps via cell towers in order to support the management of asymptomatic and presymptomatic carriers of the severe acute respiratory syndrome 2 (SARS-CoV-2) placed under home isolation, ensures they stay in their isolation area and protect personal privacy and to prevent contact with uninfected persons [9]. The effectiveness of digital fences was reported [10].

Although McDermott stating herd immunity is important [3], unless one of the five reasons for the herd immunity model is met, the promise of herd immunity will not be fulfilled [11]. In other words, five reasons or conditions must be satisfied for fulfilling the promise of herd immunity.

Aschwanden identified five reasons why herd immunity is not achieved [12]:

1) It's unclear whether vaccines prevent transmission,
2) Vaccine roll-out is uneven,
3) New variants change the herd-immunity equation,
4) Immunity might not last forever, and
5) Vaccines might change human behaviour.

In other words, five reasons or conditions should be managed or satisfied: 1) clarification of vaccine prevention against COVID-19 transmission, 2) vaccine should be spread evenly and globally, 3) vaccines should support new variants with spike mutations and immune escape, 4) how to handle immunity of vaccines degrading over time, and 5) how to control human behaviour changes of vaccinated people.

The first condition can be met with rigorous study. But, the second condition is difficult to meet because every country is selfish. The third condition is that it takes time to develop a new vaccine. The fourth condition can be managed by booster shots. The last condition is also difficult to control. Because, vaccinated people tend to be relieved and neglect to wear masks, wash their hands, and keep a social distance, which in turn contributes to the spread of infection. The human behaviour control may be the most difficult.

Harvey et al. summarized mutations of the SARS-CoV-2 spike protein and immune escape with emerging evidence of variants exhibiting resistance to antibody-mediated immunity elicited by vaccines [13–15]. Immune escape or vaccine escape of COVID-19 variants was reported [16–20]. This means that a new vaccine is needed immediately to support or cope with new variants with spike mutations and immune escape. Many researchers have been working on redesigning vaccines against COVID-19 variants [21, 22].

The first goal of this paper is to investigate whether satisfying herd immunity threshold with a pharmacological approach can mitigate the COVID-19 pandemic or not. The first tool, deathdaily [1] was used to investigate Aschwanden's first condition. In other words, the tool showed that the pharmacological approach alone cannot mitigate the pandemic.

The second goal is to examine whether good strategies with a non-pharmacological approach can mitigate the pandemic or not. The second tool, scorecovid [2] was used to examine the effectiveness of non-pharmacological approach which can solve Aschwanden's fifth condition. In other words, scorecovid will be used to show that digital fences are effective in solving.

This paper examines 7 countries such as the US, UAE, the UK, France, and Canada on scoring individual policies based on the number of deaths due to COVID-19 per population (in millions).

2 Methods and result

The first tool, deathdaily [1] was used to investigate whether vaccinated countries with satisfied or nearly satisfied herd immunity threshold can mitigate the pandemic or not. Continuous daily deaths are a good indicator of policy outcomes. In other words, deathdaily is a tool to visualize the number of deaths in each country, as already described, but in this study, deathdaily was used to compare the number of deaths with vaccination coverage.

The second tool, scorecovid [2] was used to examine whether non-pharmacological approaches such as digital fences can mitigate the COVID-19 pandemic or not. Scores

are accumulated metrics that show the outcome of a policy. The lower the score, the better the policy. In other words, scorecovid is also a tool for scoring each country's policies as already written, but in this study, scorecovid was used to verify whether countries with digital fence policies that restricted human behavior, including vaccinators, had better scores.

The deathdaily [1]. is available in public and can be easily installed by PyPI package for predicting the number of daily deaths in the next seven days. According to https://pepy.tech/project/deathdaily, the deathdaily has been downloaded by 19,660 users worldwide. The reproducibility is validated with codeocean: https://doi.org/10.24433/CO.1663204.v2

The scorecovid [2]. is also available in public and can be installed by PyPI package with 10,933 users in the world. The reproducibility is validated with codeocean: https://doi.org/10.24433/CO.9411531.v1

This paper shows the robust evidence using five vaccinated countries such as the US, UAE, the UK, France and Canada with the strong resurgence of COVID-19. The number of daily deaths is a good indicator for analyzing the pandemic.

Figure 1 was generated by the following command with 300 days and the 6th degree polynomial regression for the number of daily deaths in the US:

$ deathdaily 'United States' 300 6.

The black line in Fig. 1 shows the number of daily deaths due to COVID-19 in the US. The result in Fig. 1 depicts the strong resurgence of COVID-19 pandemic although the US is with 63.9% fully vaccinated and 75.7% at least one dose as of Jan.27, 2022. r2 (R-squared) is 0.41. R-squared (r2) is a statistical measure of how close the data are to the fitted regression line. In Fig. 1, the 6th degree polynomial
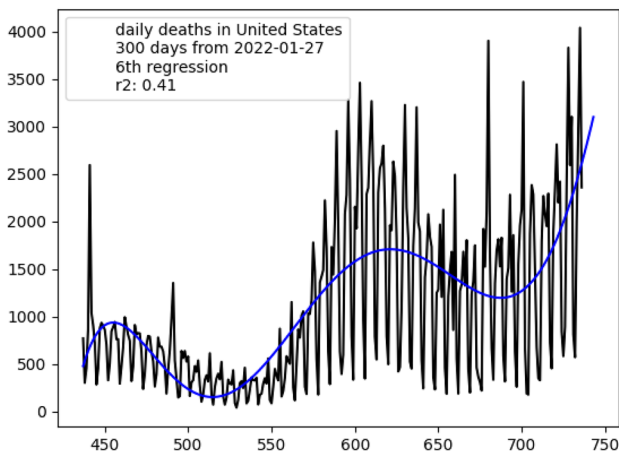

Fig. 2 the number of daily deaths in UAE as of Jan.27, 2022

regression is used. The blue colored line indicates the prediction of the next seven days from Jan.27, 2022.

Figure 2 was similarly generated by 200 days and the 6th degree polynomial regression. It shows that UAE is in the midst of the resurged pandemic with 92.9% fully vaccinated and 99.9% at least one dose as of Jan.27, 2022. r2 is 0.626The UAE has the highest vaccination rate in the world.

Figure 3 shows that of the UK with 300 days and the 6th degree polynomial regression. The UK is also in the midst of the pandemic with 70.8% fully vaccinated and 77% at least one dose as of Jan.27 2022. r2 is 0.581.

Figure 4 shows that of France with 200 days and the 6th degree polynomial regression. France is in midst of the strong resurgence with 76.1% fully vaccinated and 79.6% at least one dose as of Jan.27, 2022. r2 is 0.653.

Fig. 1 the number of daily deaths in the US as of Jan.27, 2022 300 days from Jan.27 2022 were used for the curve-fitting with the 6th polynomial regression
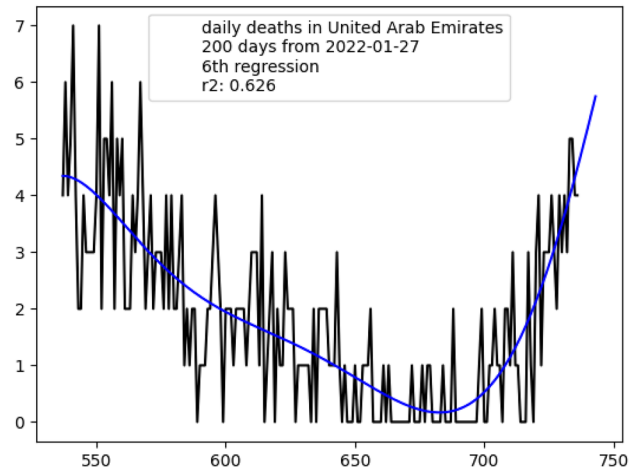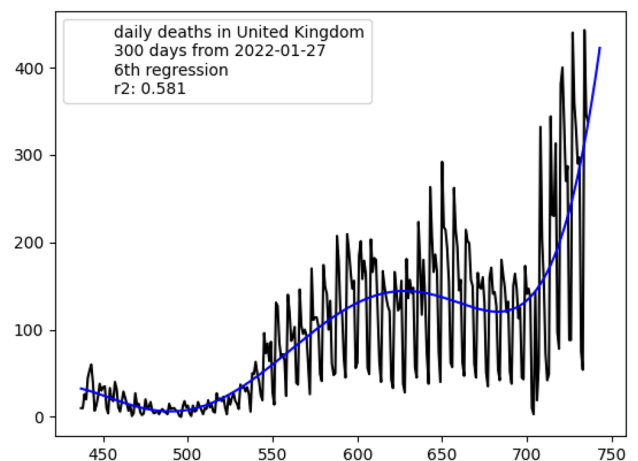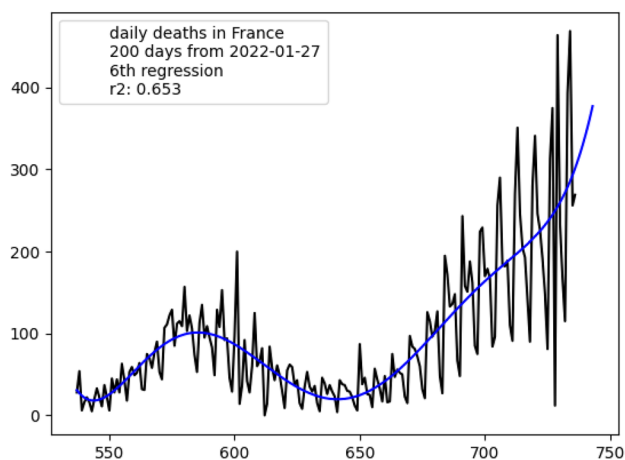

Fig. 3 the number of daily deaths of the UK as of Jan.27, 2022

Fig. 4 the number of daily deaths of France as of Jan.27, 2022

country	deaths	population	score
New Zealand	52	4.82	10.8
Taiwan	851	23.82	35.7
United Arab Emirates	2232	9.89	225.7
Canada	33368	37.74	884.2
France	130082	65.27	1993
United Kingdom	155169	67.89	2285.6
United States	878424	331	2653.8

Fig. 6 Scoring 7 countries (score = deaths/population (in millions))

Figure 5 shows that of Canada with 200 days and the 7th degree polynomial. Canada is in midst of the strong resurgence with 78.8% fully vaccinated and 79.6% at least one dose as of Jan.27, 2022. r2 is 0.758.

All figures (Figs. 1–5) were generated by deathdaily with the country name, the number of days, and the nth degree of regression polynomial for the next seven days in prediction (blue colored line).

All figures (Figs. 1–5) indicate that a significant resurgence of daily mortality with COVID-19 has been observed in fully vaccinated countries (the US, UAE, the UK, France, and Canada).

Although the US, UAE, the UK, France and Canada satisfy the herd immunity threshold, the herd immunity has never been achieved because of new COVID-19 variants with spike mutations and immune escape.

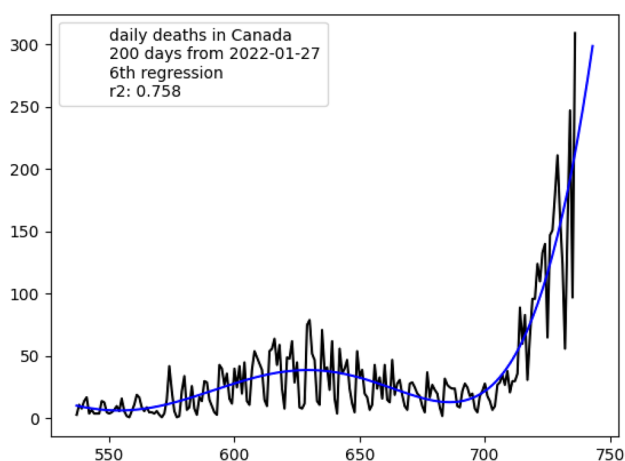Figures 1–5 suggest us that spike mutations and immune escape may force us to update the current policy against COVID-19. In other words, more effective strategies or policies including "digital fences" should be used for mitigating and ending the COVID-19 pandemic. Digital fences and new vaccines against new variants with spike mutations and immune escape may be immediately needed worldwide.

The following site will be useful for readers to check the vaccination coverage data for each country.

https://ourworldindata.org/covid-vaccinations

Figure 6 shows the effectiveness of digital fences of Taiwan and New Zealand over four non-digital fencing countries (the US, the UK, Canada, and France). In Fig. 6, two different groups are observed: one with a score below 100 and the other with a score above 800.

3 Conclusion

The first deathdaily tool revealed that the COVID-19 death resurgence is observed in vaccinated countries (the US, UAE, the UK, France and Canada) with satisfied herd immunity threshold. Daily deaths are a good indicator of policy outcomes.

The second scorecovid tool discovered that non-pharmacological approach such as digital fencing is very effective to mitigate the COVID-19 death. Scores by scorecovid are accumulated metrics that show the outcome of an individual policy. In order to mitigate and end the COVID-19 pandemic, a multipronged approach such as a pharmacological approach and a non-pharmacological approach is immediately needed worldwide. A new vaccine to impede COVID-19 may be needed to support or cope with new variants with spike mutations and immune escape.

Declarations

Ethics approval Not Applicable.

Fig. 5 the number of daily deaths of Canada as of Jan.27, 2022

Consent to participate Not Applicable.

Consent for publication Not Applicable.

Conflicts of interest The author has no conflict of interest.

References

1. Takefuji Y. Deathdaily: A Python Package Index for predicting the number of daily COVID-19 deaths. Netw Model Anal Health Inform Bioinforma. 2022;11:14. https://doi.org/10.1007/s13721-022-00359-1.

2. Takefuji Y. SCORECOVID: A Python Package Index for scoring the individual policies against COVID-19. Healthcare Analytics. 2021;1:100005.

3. Szumlinski Angie. Herd Immunity. 2021. https://www.healthcapusa.com/blog/herd-immunity-2/.

4. Rubin R. Difficult to Determine Herd Immunity Threshold for COVID-19. JAMA. 2020;324(8):732. https://doi.org/10.1001/jama.2020.14778.

5. McDermott A. Herd immunity is an important—and often misunderstood—public health phenomenon. PNAS. 2021;118(21):e2107692118. https://doi.org/10.1073/pnas.2107692118.

6. Fine PE. Herd Immunity: History, Theory, Practice. Epidemiol Rev. 1993;15(2):265–302.

7. Fine P, et al. "Herd Immunity": A Rough Guide, Clinical Infectious Diseases. 2011;52(7):911–16. https://doi.org/10.1093/cid/cir007.

8. Murray Christopher JL. COVID-19 | The Myth of Herd Immunity. 2020. http://www.healthdata.org/video/covid-19-myth-herd-immunity.

9. Takefuji Y. Open Schools, Covid-19, and Child and Teacher Morbidity in Sweden. N Engl J Med 2021; 384:e66. https://doi.org/10.1056/NEJMc2101280.

10. Takefuji Y. Analysis of digital fences against COVID-19 Health and Technology. 2021b. https://doi.org/10.1007/s12553-021-00597-9.

11. Aschwanden C. The false promise of herd immunity for COVID-19. Nature. 2020;587:26–28. https://doi.org/10.1038/d41586-020-02948-4.

12. Christie A. Five reasons why COVID herd immunity is probably impossible. Nature. 2021;591:520–2. https://doi.org/10.1038/d41586-021-00728-2.

13. Harvey WT, Carabelli AM, Jackson B, et al. SARS-CoV-2 variants, spike mutations and immune escape. Nat Rev Microbiol. 2021;19:409–24. https://doi.org/10.1038/s41579-021-00573-0.

14. Ozono S, Zhang Y, Ode H, et al. SARS-CoV-2 D614G spike mutation increases entry efficiency with enhanced ACE2-binding affinity. Nat Commun. 2021;12:848. https://doi.org/10.1038/s41467-021-21118-2.

15. Guruprasad L. Human SARS CoV-2 spike protein mutations. Proteins. 2021;89(5):569–76. https://doi.org/10.1002/prot.26042. Epub 2021 Jan 17. PMID: 33423311; PMCID: PMC8014176.

16. Cobey S, Larremore DB, Grad YH, et al. Concerns about SARS-CoV-2 evolution should not hold back efforts to expand vaccination. Nat Rev Immunol. 2021;21:330–5. https://doi.org/10.1038/s41577-021-00544-9.

17. Giordano G, Colaneri M, Di Filippo A, et al. Modeling vaccination rollouts, SARS-CoV-2 variants and the requirement for non-pharmaceutical interventions in Italy. Nat Med. 2021;27:993–8. https://doi.org/10.1038/s41591-021-01334-5.

18. Gog JR, Hill EM, Danon L, Thompson RN. Vaccine escape in a heterogeneous population: insights for SARS-CoV-2 from a simple model. Royal Soc Open Sci. 2021;8(7):210530. https://doi.org/10.1098/rsos.210530. PMID: 34277027; PMCID: PMC8278051.

19. Tregoning JS, Flight KE, Higham SL, et al. Progress of the COVID-19 vaccine effort: viruses, vaccines and variants versus eff0icacy, effectiveness and escape. Nat Rev Immunol. 2021. https://doi.org/10.1038/s41577-021-00592-1.

20. Collier DA, De Marco A, Ferreira IATM, et al. Sensitivity of SARS-CoV-2 B.1.1.7 to mRNA vaccine-elicited antibodies. Nature. 2021;593:136–41. https://doi.org/10.1038/s41586-021-03412-7.

21. Callaway E, et al. How to redesign COVID vaccines so they protect against variants. Nature. 2021;590:15–6. https://doi.org/10.1038/d41586-021-00241-6.

22. Takefuji Y. Artificial Intelligence Suggests that UAE Needs to Mitigate the Small COVID-19 Resurgence. Dubai Medical Journal. 2021;4(1):74–6. https://doi.org/10.1159/000514590.